

In the secondary canning module, primary cans would be placed into secondary stainless steel storage cans meeting DOE's long-term storage requirements. Also in this module, secondary storage cans would be welded shut and leak tested. After leak testing, each can would be marked with a laser to identify the can and its contents, and passed to the nondestructive assay module. For alternatives where the pit conversion facility would be collocated with the MOX facility (or the immobilization facility for immobilization-only alternatives), and the plutonium dioxide would not need to be transported between sites, use of only a primary can, or another less rigorous primary and secondary can arrangement, may be used.

In the nondestructive assay module, each can would be assayed to confirm its contents. Following assay, the cans would be moved into the main storage vault and would be available for international inspection. After inspection, the cans would be transferred to another vault that would also be subject to international inspection. For the disposition alternatives being studied in this SPD EIS, the storage containers would be transferred to either the immobilization facility or the MOX facility. All offsite shipments would be in DOE SST/SGTs.

2.4.2 Plutonium Conversion and Immobilization

The immobilization facility would perform two operations on the surplus nonpit plutonium materials described in Section 2.2: (1) conversion of miscellaneous surplus plutonium that is not in pit form into plutonium dioxide for immobilization; and (2) immobilization of this plutonium dioxide, and possibly the plutonium dioxide from pits (if it were decided to also immobilize plutonium from pits), in a ceramic or glass form. This material would then be sealed in cans, and these cans would be placed inside canisters that would subsequently be filled with vitrified HLW from either the HLW vitrification facility at Hanford or DWPF at SRS (i.e., the can-in-canister approach). Filled and sealed waste canisters would be placed into storage for ultimate disposition in a potential geologic repository pursuant to the Nuclear Waste Policy Act (NWPA). The immobilization facility would be open to international inspection.

2.4.2.1 Immobilization Facility Description

The immobilization facility would consist of two primary components: a main process building and an HLW vitrification facility. It would be designed to immobilize up to 5 t/yr (5.5 tons/yr) of plutonium metal. This annual throughput would consist of up to 1.7 t (1.9 tons) of surplus nonpit plutonium and up to 3.3 t (3.6 tons) of surplus plutonium derived from pits. Operation of the facility would involve three shifts 7 days per week, and would require a workforce ranging from about 335 to 412 personnel.⁷ For 11 of the alternatives considered in this SPD EIS, a total plutonium immobilization throughput of 17 t (19 tons) was assumed. These alternatives involve the hybrid approach of disposition through both immobilization and MOX fuel fabrication. Four alternatives involve disposition only by immobilization, and the facility design for the two candidate sites would accommodate the assumed 50-t (55-ton) throughput of plutonium metal. The lower throughput for the hybrid approach would be reflected in differences in operational employment and resource requirements, but would not affect construction requirements.

The immobilization facility would be at either Hanford or SRS. At Hanford, the immobilization facility would occupy parts of both FMEF and the HLW vitrification facility planned to be constructed to support Hanford's tank waste remediation system. At SRS, immobilization would occur in a new building near the planned Actinide Packaging and Storage Facility (APSF), and at DWPF.

⁷ Personnel needed to operate the planned HLW vitrification facility at Hanford, or DWPF at SRS, are not included because these facilities are required regardless of the immobilization alternatives presented in this SPD EIS.

DOE is preparing a supplemental environmental impact statement (SEIS) (DOE/EIS-0082-S2) on the proposed replacement of the In-Tank Precipitation (ITP) process at SRS (64 FR 8558, February 22, 1999). The ITP process was intended to separate soluble high-activity radionuclides (mainly cesium, with trace amounts of strontium, uranium, and plutonium) from liquid HLW before vitrifying this high-activity fraction of the waste in DWPF⁸ and disposing of the remaining low-activity fraction as saltstone in vaults at SRS. Initial ITP testing and operation, and subsequent studies, have demonstrated that the ITP process as presently configured cannot meet production goals and safety requirements for processing HLW.

As part of the surplus plutonium disposition program, DOE is proposing to take advantage of its HLW vitrification capabilities by using the high-activity fraction of the HLW as the source of radiation to meet the “Spent Fuel Standard” for immobilized surplus plutonium. As noted in Chapter 1, the “Spent Fuel Standard,” as modified by DOE, specifies that surplus plutonium must be roughly as inaccessible and unattractive for weapons use as the much larger and growing stock of plutonium in civilian spent nuclear fuel. Since the early 1980s, a great deal of research and engineering effort has been devoted to the development of technologies to separate the high-activity radionuclides from the other constituents in HLW.

Due to problems experienced with ITP operation, DWPF is currently operating with sludge feed only. A thorough search for alternatives using a disciplined systems engineering approach identified two viable processes (ion exchange and small tank precipitation) for separating the high-activity fraction from HLW and sending this fraction to DWPF. Extensive laboratory and bench-scale testing has been conducted on both of these processes using both simulated and actual HLW. Test results indicate that either process is capable of separating the high-activity radionuclides from HLW at SRS and feeding these high-activity radionuclides to DWPF, although further research and development is necessary. An independent team chartered by DOE’s Assistant Secretary for Environmental Management has conducted a review of the alternatives evaluation process and supported the selection of these two processes (DOE 1998c).⁹ Designation of a preferred process and construction of a pilot plant for scale-up of the selected process are the next steps planned to resolve this issue. This would mark a transition from proof-of-concept testing to engineering and process scale-up operations. As such, DOE would expect the remaining uncertainties could be resolved through engineering of the process and components rather than development of a new technology.

In addition to small tank precipitation and ion exchange alternatives, the SEIS will also analyze a third action alternative, direct grout, in light of technical and cost considerations. Under the direct grout alternative, the cesium component of the high-activity radionuclides would be entombed in grout (for surface disposal) rather than remaining in the high-activity fraction provided to DWPF for vitrification and eventual disposal in a potential geologic repository. Therefore, the direct grout alternative would not provide the radiation barrier needed to meet the spent fuel standard for surplus plutonium disposition.

A DOE waste management requirement (DOE Manual 435.1, *Radioactive Waste Management*, Section II.B.2) provides that, for direct grout material to be disposed of as now being analyzed, “key radionuclides would have to be removed to the maximum extent that is technically and economically practical.” This criterion would not be met in the event that either of the other alternatives is determined to be viable after further evaluation.

⁸ The HLW in the SRS storage tanks is composed of liquid and sludge (high-activity insoluble waste that has settled to the bottom of the tanks) fractions that are treated separately before being vitrified together in DWPF. During the vitrification process, this high-activity sludge is intended for blending in specific ratios with the concentrated high-activity liquid from ITP to form a slurry feed for DWPF.

⁹ The National Research Council (the Council) is also evaluating alternatives to the ITP process. The Council’s study committee issued an interim report in October 1999 (NC 1999). This committee recommends further research and development for the ion exchange and small tank precipitation alternatives, and for caustic side solvent extraction, a third process that would separate high-activity radionuclides that could be sent to DWPF.

Therefore, DOE regards the direct grout alternative as reasonable only if both the ion exchange and small tank precipitation alternatives analyzed in the SEIS prove not to be viable.

In summary, although the method for providing the HLW needed for the can-in-canister immobilization alternatives for surplus plutonium disposition has not been determined, DOE is confident that the technical solution will be available at SRS by using radioactive cesium either from the ion exchange or small tank precipitation process.

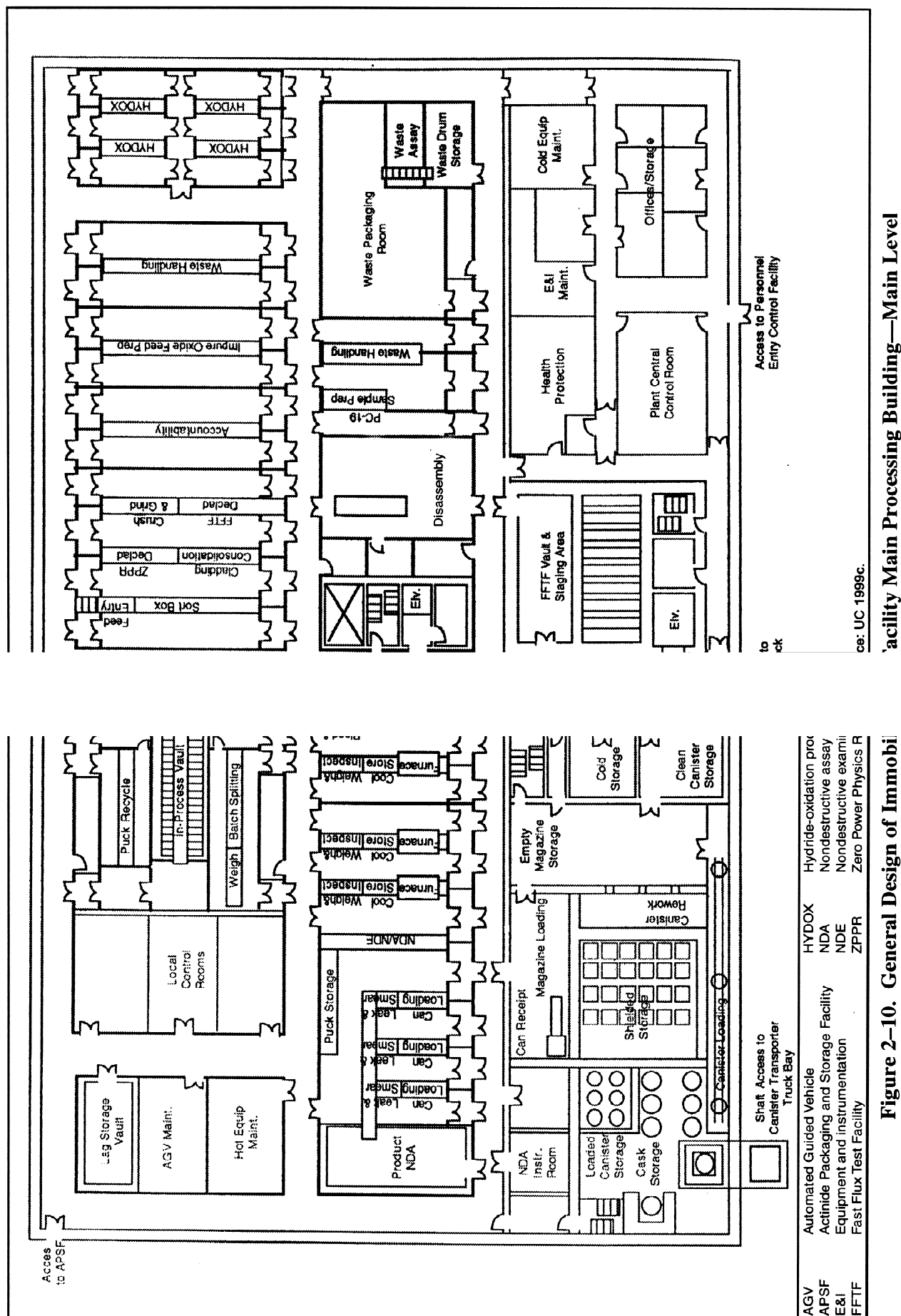
Since the issuance of the SPD Draft EIS, DOE has developed a more detailed conceptual design for the can-in-canister immobilization facility. Some of the design changes include lengthening the process gloveboxes by about 35 percent; doubling the material conveyor length; changing to a vertical ceramification stack that affected the configuration of the second level of the facility; increasing the heating, ventilation, and air-conditioning systems and electrical support to correspond to the increased process space; enlarging the space required for maintenance activities; and increasing the size of the canister-loading area. To accommodate these design modifications, the proposed immobilization facility has approximately doubled in size in terms of floor space.

A general layout for the immobilization facility main process building is depicted in Figures 2–10 and 2–11. This layout approximates how the immobilization process would be implemented. However, the layout and design of the facility would vary depending on whether the facility were proposed as a new building, located in an existing building, or collocated in an existing building with either the pit conversion or MOX facility; and which immobilization process were selected. In addition to the main process building, the planned HLW vitrification facility at Hanford, or the existing DWPF at SRS, would be used in part of the immobilization process. Activities at these facilities would include canister receipt and unloading, canister filling with HLW, decontamination, and closure. The design of the Hanford HLW vitrification facility would be modified as needed before the facility would be constructed. DWPF would have to be modified slightly to accommodate the proposed immobilization activities. Modifications to DWPF would be needed to enable the receipt and storage of canisters containing immobilized plutonium. This would include modifications to security features as well as material handling systems. Minor changes within DWPF material processing or handling areas would be completed remotely. Construction worker exposures resulting from these modifications are expected to be negligible.

The main process building would house the following functions: material receiving, feed material storage, unpacking and sorting operations, fuel decladding, metal-to-oxide conversion, calcination, halide removal, sample preparation and product assay, in-process storage, feed blending and preparation, immobilization of the plutonium using either a ceramic or glass process, can loading, and canister loading. Separate truck bays would be designed to accommodate the DOE SST/SGTs that would be used to transport plutonium feed materials.

The main process building would be a reinforced concrete structure meeting all applicable standards for the processing of special nuclear material. Areas of the building in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with the fissile and radioactive materials. Ancillary buildings would be required for support activities.

Confinement barriers would separate the immobilization facility into zones so as to control the spread of any airborne contamination. The exhaust from process operations would be properly confined, filtered, and monitored prior to release. The facility would have heating, ventilation, and air-conditioning systems and HEPA filters, with provisions for redundant trains of HEPA filters and equipment to facilitate maintenance activities such as filter cleaning while maintaining zone-regulated air flow. An uninterruptible power supply



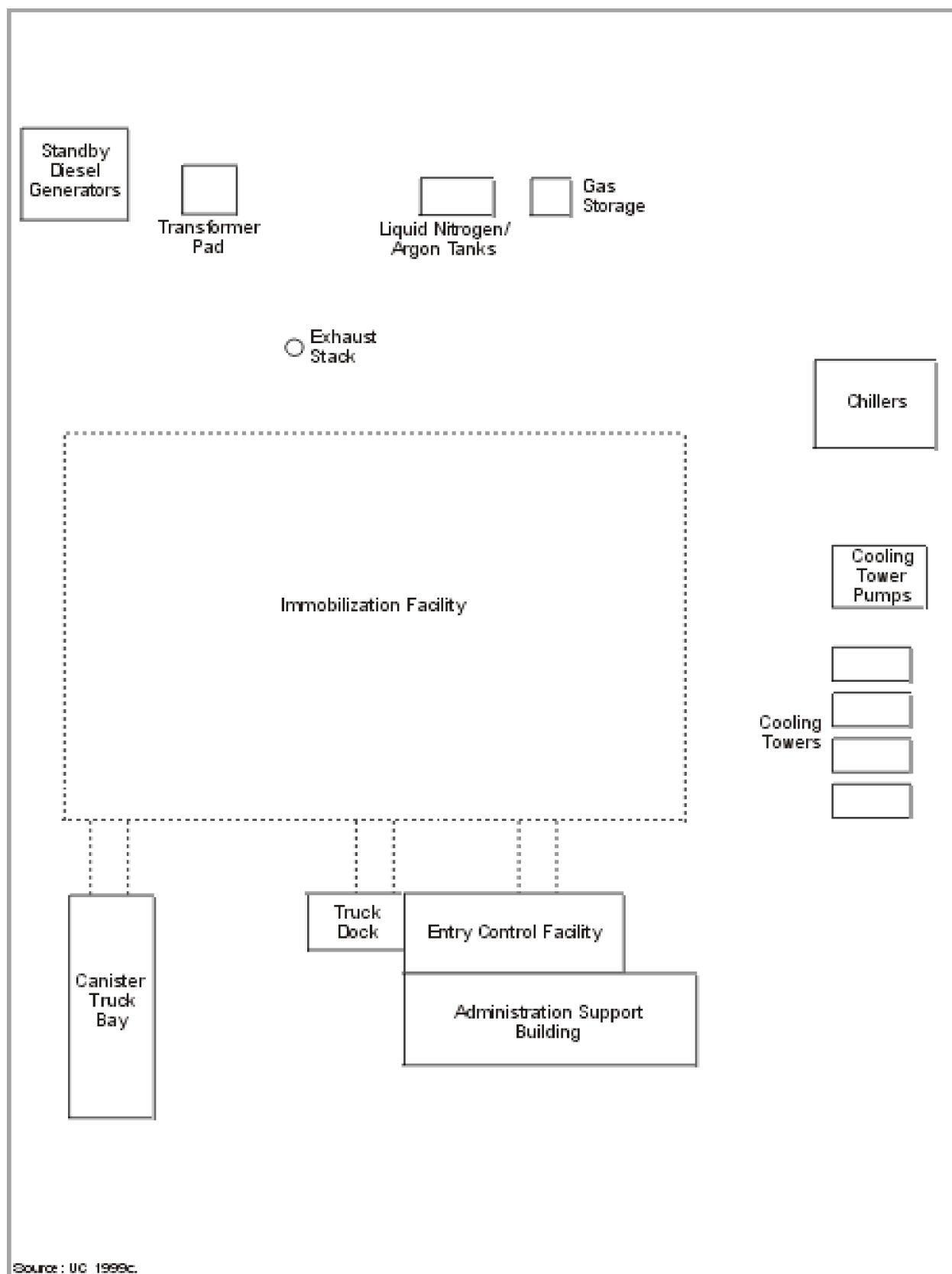


Figure 2–11. General Design of Immobilization Facility Main Processing Building—Above-Grade Structures

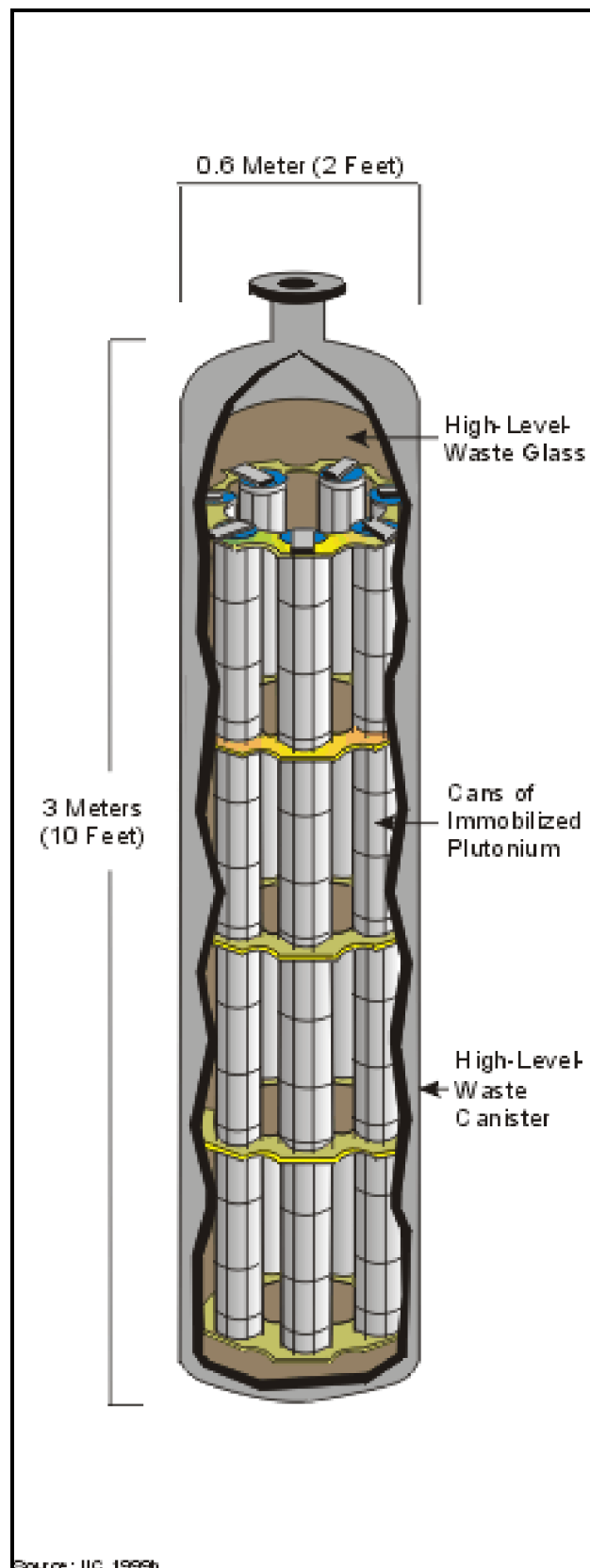


Figure 2-12. Cutaway View of Can-in-Canister Approach

and standby generators would provide backup power for critical systems. This arrangement would ensure that critical systems remain operational during any interruption of offsite power.

2.4.2.2 Plutonium Conversion and Immobilization Process

The plutonium conversion and immobilization process would have the capability to immobilize surplus plutonium material from both pit and nonpit sources. Surplus plutonium derived from pits and already processed by the pit conversion facility would be directly suitable for immobilization, whereas most surplus nonpit plutonium would first have to be converted to a suitable oxide. These oxides would then be incorporated into either a titanate-based ceramic material or a lanthanide borosilicate glass.

The plutonium immobilized in ceramic or glass would be placed inside stainless steel cans, which would be welded shut. The cans would be loaded into an HLW canister (similar to the type currently in use at DWPF at SRS), and filled with HLW to provide a radiation barrier that contributes to the proliferation resistance of the final product. The filled canister, as depicted in Figure 2-12, would then be sealed and stored on the site pending final disposition in a potential geologic repository pursuant to the NWSA. Figure 2-13 provides an overview of the ceramic and glass can-in-canister immobilization processes.

2.4.2.2.1 Plutonium Conversion Process

Plutonium feed materials would be transported in DOE SST/SGTs from the pit conversion facility (if not collocated with the immobilization facility) and the DOE sites storing surplus nonpit plutonium. The shipping containers would be unpacked and the nuclear material assayed at the immobilization facility. Several forms of surplus plutonium materials, all unclassified, would be received by the facility: unirradiated metal reactor fuel in the form of pins and plates clad in stainless steel (from the Zero Power Physics Reactor [ZPPR] at INEEL), unirradiated oxide reactor fuel consisting of fuel pins and bundles (from the Fast Flux Test Facility [FFTF] at Hanford), plutonium alloys, metals, and

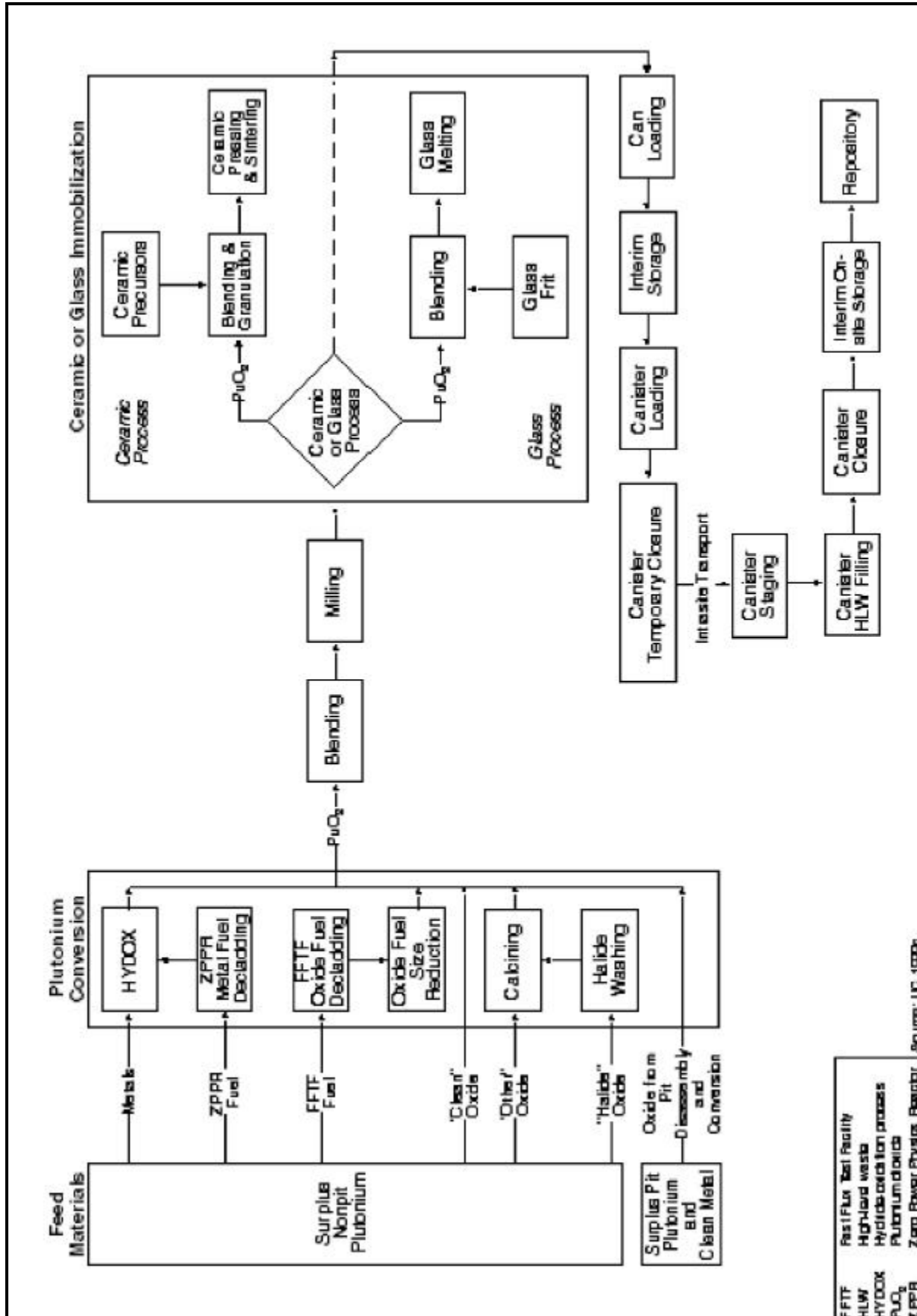


Figure 2-13. Can-in-Canister Process

oxides. Some of these feed materials would also have a uranium component. A feed material storage vault would be available to store up to 6 months of incoming plutonium feed materials. Individual containers would be transferred from the feed material storage vault to a glovebox, unpacked, and inspected to determine the conversion process necessary to render the feed material suitable for immobilization. Metals and alloys would be converted to oxide using the HYDOX process. Metal reactor fuel may require decladding before HYDOX conversion. Oxide reactor fuel would also be decladded, and the individual fuel pellets removed and sorted according to fissile material content. Pellets containing plutonium or enriched uranium would then be ground to an acceptable particle size. Oxides containing moisture or impurities would undergo a calcining process; oxides containing significant concentrations of halide impurities would be “washed” with water to remove the halides before calcining could take place.

Following these conversion processes, the plutonium materials would be stored in the in-process storage vault. Clean oxides—in particular, oxides received from the pit conversion facility, if the decision were made to immobilize all the surplus plutonium—would not require conversion and would be transferred directly to the vault.

2.4.2.2.2 Immobilization Process

Ceramic Process. The ceramic immobilization process would be conducted in a series of glovebox operations that would incorporate the plutonium oxide into ceramic disks, stack the disks inside stainless steel cans, and load the cans into an HLW canister.

In the feed-blending step, plutonium dioxide feed materials would be selected from in-process storage for blending with depleted uranium dioxide. Uranium dioxide would be added to generate a consistent product and reduce criticality concerns, and neutron absorbers (for example, the elements gadolinium or hafnium) would be added to provide criticality safety in the ceramic product. As explained in Section 1.5, uranium dioxide made from depleted uranium hexafluoride in storage at the gaseous diffusion plants previously operated by DOE, such as the Portsmouth Gaseous Diffusion Plant, would be used for this purpose.

After blending, each batch of feed material would be milled to reduce the size of the oxide powder, then blended with ceramic precursors. This mixture would then be granulated with an organic binder to produce a pourable feed that would hold together adequately when compacted into disks. In the press and sinter step, the mixture would be fed into a hydraulic press to form disks, which in turn would be baked in a furnace for reactive sintering to produce the desired mineral phases in the ceramic form. The final product would consist of homogeneous disks about 6.3 cm (2.5 in) in diameter by 2.5 cm (1 in) in height, containing about 10 weight-percent plutonium and 20 weight-percent uranium. These disks would then be stacked and sealed inside stainless steel cans. The cans would be leak tested, assayed, loaded into magazines, and stored in the product vault until removed for canister-filling operations.

As needed, magazines of canned ceramic disks would be removed from storage and inserted and locked into a framework inside an HLW canister. A temporary closure plug would be installed, and following leak testing, the canister would be loaded into a shielded transportation box for intrasite shipment from the main process building to the HLW vitrification facility in a specialized canister transport vehicle.

Glass Process. The glass immobilization process would be conducted in a series of glovebox operations that would incorporate the plutonium oxide into molten lanthanide borosilicate glass, pour it into stainless steel cans, and load the cans into an HLW canister.

In the feed-blending step, plutonium oxide feed materials would be selected from in-process storage for blending to produce individual batches with the desired isotopic composition. Each batch would be milled to reduce the

size of the oxide powder to achieve faster dissolution during the melting process. The milled oxide would then be blended with glass frit (small glass pebbles) containing neutron absorbers (e.g., gadolinium and hafnium) to form a mixture of about 8 weight-percent plutonium and 3 to 8 weight-percent uranium.

This mixture would be fed at a controlled rate into electrically heated melters operating at about 1,500 °C (2,732 °F) to melt the frit and dissolve the plutonium oxide. The homogenous glass melt would be drained into stainless steel cans, which in turn would be sealed, leak tested, assayed, loaded into magazines, and stored in the product vault. As needed, these magazines would be removed from storage and inserted and locked into a framework inside an HLW canister. A temporary closure plug would be installed, and following leak testing, the canister would be loaded into a shielded transportation box for intrasite shipment from the main process building to the HLW vitrification facility in a specialized canister transport vehicle.

Canister Filling. Canister filling, the last major step of the immobilization process, would occur at the HLW vitrification facility. The canisters received from the main process building would be moved individually through an inspection area to the HLW melt cell. In the melt cell, molten, vitrified HLW would be poured into the canister around the stainless steel cans of immobilized plutonium. After removal of any contamination from its outside surface, the canister would be plugged and welded closed. Following inspection and verification that the exterior of the canister was free of contamination, the canister would be transported to an onsite storage vault for interim storage pending final disposition at a potential geologic repository pursuant to the NWPA.

The HLW canisters would measure 0.6 m (2 ft) in diameter by 3 m (10 ft) in height, and, when filled, would weigh up to 2,500 kg (5,500 lb).¹⁰ As each canister of plutonium immobilized in ceramic would contain about 28 kg (61 lb) of plutonium,¹¹ about 1,820 of these canisters would be required to process all 50 t (55 tons) of surplus plutonium. In the ceramic process, the cans, magazines, and internal framework within each canister would displace approximately 15 percent (by volume) of HLW glass. This would result in 272 canisters more than otherwise planned for the DOE HLW vitrification program. Each canister of plutonium immobilized in glass would contain about 26 kg (58 lb) of plutonium.¹¹ As such, about 1,900 canisters would be required to vitrify the 50 t (55 tons) of surplus plutonium. Because the cans, magazines, and internal framework used in the glass process would displace approximately 21 percent (by volume) of HLW glass, this would result in 395 canisters more than otherwise planned for the DOE HLW vitrification program. For the hybrid alternatives, about 670 canisters of plutonium immobilized as a ceramic or 690 canisters of vitrified plutonium would be produced. This would result in 101 or 145 additional canisters, depending on whether the immobilized form were ceramic or glass, respectively, than otherwise planned for the DOE HLW vitrification program.

2.4.3 MOX Fuel Fabrication

The MOX facility would produce completed MOX fuel assemblies for use in domestic, commercial reactors. Feed materials would be the plutonium dioxide from the pit conversion facility and uranium dioxide made from either the DOE stockpile of depleted uranium hexafluoride at a representative DOE site (i.e., the Portsmouth Gaseous Diffusion Plant) or another source selected by the fuel fabricator (DCS) and approved by DOE. MOX fuel fabrication involves blending the plutonium dioxide with uranium dioxide; forming the mixed oxide into pellets; loading the pellets into fuel rods; and assembling the fuel rods into fuel assemblies. Once assembled, each of the fuel assemblies would be transported in SST/SGTs to one of the domestic, commercial reactors for

¹⁰ Consistent with the *Storage and Disposition PEIS* and the WM PEIS, the DWPF HLW canister has been used as the reference canister design for the surplus plutonium immobilization program. Although DOE is considering the possibility of using a larger canister for the Hanford HLW vitrification program, the analyses in this SPD EIS also assume that a DWPF-type canister would be used at Hanford.

¹¹ Plutonium loading in the final design specification and between individual canisters may vary slightly.

use as fuel. Following irradiation, the MOX fuel would be removed from the reactor and managed at the reactor site as spent fuel. Final disposition would be at a potential geologic repository pursuant to the NWP.

The proposed MOX facility would also include plutonium polishing (a small-scale aqueous process) to remove impurities,¹² in particular gallium, from the plutonium dioxide feed prior to MOX fuel fabrication. This initial plutonium-polishing process would be essentially that described in Appendix N of the SPD Draft EIS, and would add approximately 2,500 m² (27,000 ft²) of process space and about 315 m² (3,400 ft²) of nonhardened space for support functions to the MOX facility. However, the MOX facility layout depicted in Figures 2–14 and 2–15 has not been revised to show this process. This layout approximates how the MOX fuel fabrication process would be implemented. It is a conceptual design that would be updated in subsequent design phases should DOE choose the hybrid approach for surplus plutonium disposition in the ROD. If so, during the design process, the plutonium-polishing component would be integrated into the MOX facility design. The potential impacts of the MOX facility, including plutonium polishing, are evaluated in Chapter 4 and would be the same regardless of where the plutonium-polishing equipment would be located within the MOX facility.

2.4.3.1 MOX Facility Description

The MOX facility would be designed to process up to 3.5 t (3.8 tons) of surplus plutonium (as plutonium dioxide from the pit conversion facility) annually. Facility operations would require a staff of about 385 personnel. The MOX facility has been increased in size from about 11,000 m² (120,000 ft²) in the SPD Draft EIS to about 20,000 m² (215,000 ft²) to include the plutonium-polishing component and additional space proposed by DCS (DOE 1999a). However, about 2,000 m² (21,000 ft²) of administrative space have been relocated from support facilities to the MOX facility, so the net increase in space needed to implement the MOX option is about 7,000 m² (75,000 ft²). As depicted in Figures 2–14 and 2–15, the MOX facility would be a two-story, hardened, reinforced-concrete structure with a below-grade basement and an at-grade first floor. The facility would meet all applicable standards for processing special nuclear material. The walls, floors, and roof of the building would be constructed of about 46 cm (18 in) thick reinforced concrete. Areas of the facility in which plutonium would be processed or stored would be designed to survive natural phenomena such as earthquakes, floods, and tornadoes, as well as potential accidents associated with processing fissile and radioactive materials. Ancillary buildings would be required for support activities.

The fuel fabrication areas, two parallel process lines, would be at ground level. To accommodate the potential for fabricating a different type of fuel, the MOX facility would have sufficient unused space for the installation of another production-scale MOX fuel line. An inert atmosphere would be maintained in gloveboxes where dictated by process needs or safety concerns. The exhaust from the gloveboxes would be monitored continuously for radioactive contamination. The atmosphere in the gloveboxes would be kept at a lower pressure than that of the surrounding areas so that any leaks of gaseous or suspended particulate matter would be contained and filtered appropriately. The building ventilation system would include HEPA filters, and would be designed to maintain confinement, thus precluding the spread of airborne radioactive particulates or hazardous chemicals within the facility and to the outside environment. Both intake and exhaust air would be filtered, and exhaust gases would be monitored for radioactivity. Power would be supplied to the MOX facility by two independent offsite power supplies. An uninterruptible power supply and standby generators

¹² Table 2–2 lists the potential impurities.

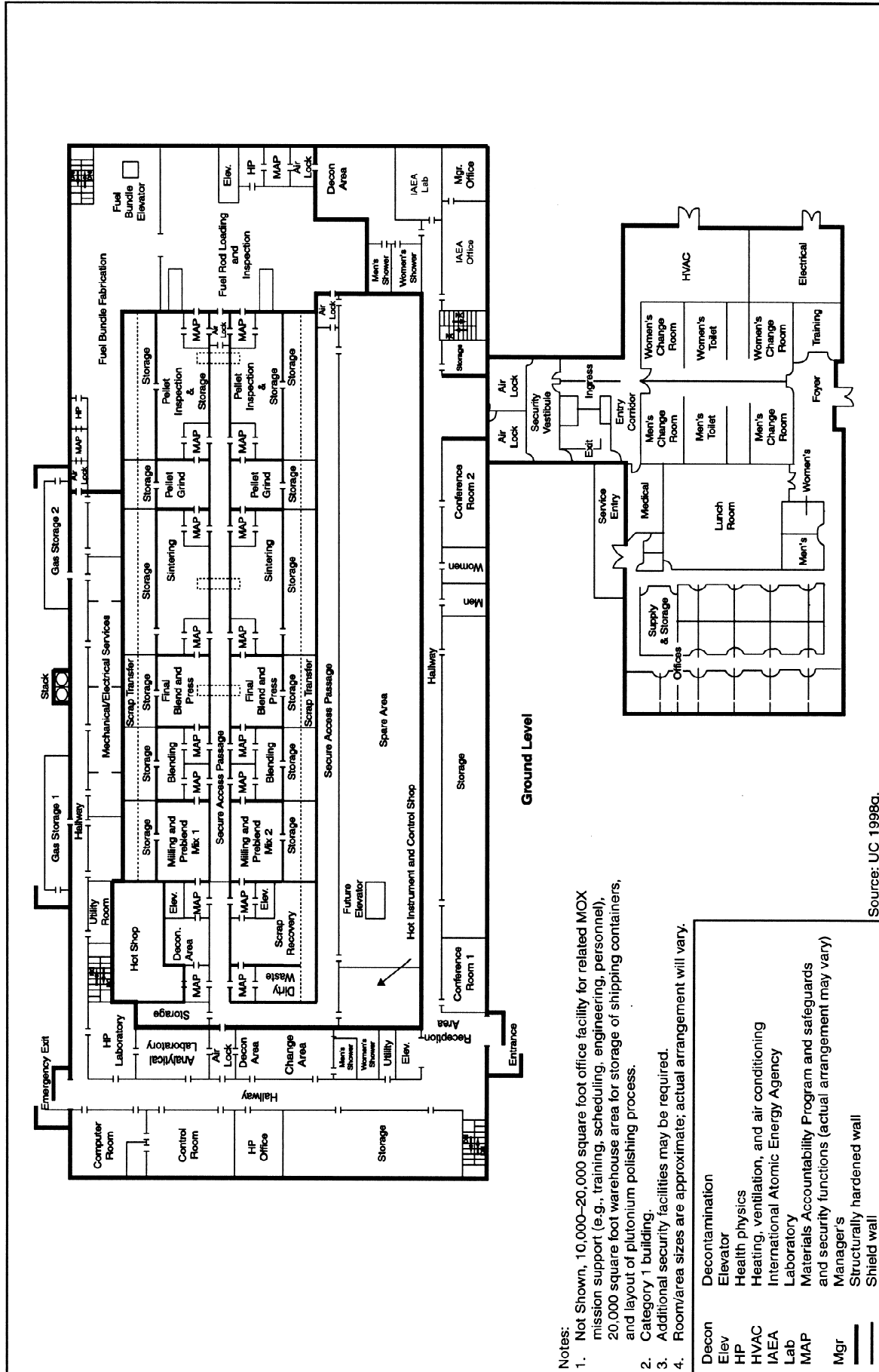


Figure 2-14. General Design of MOX Facility—Ground Level

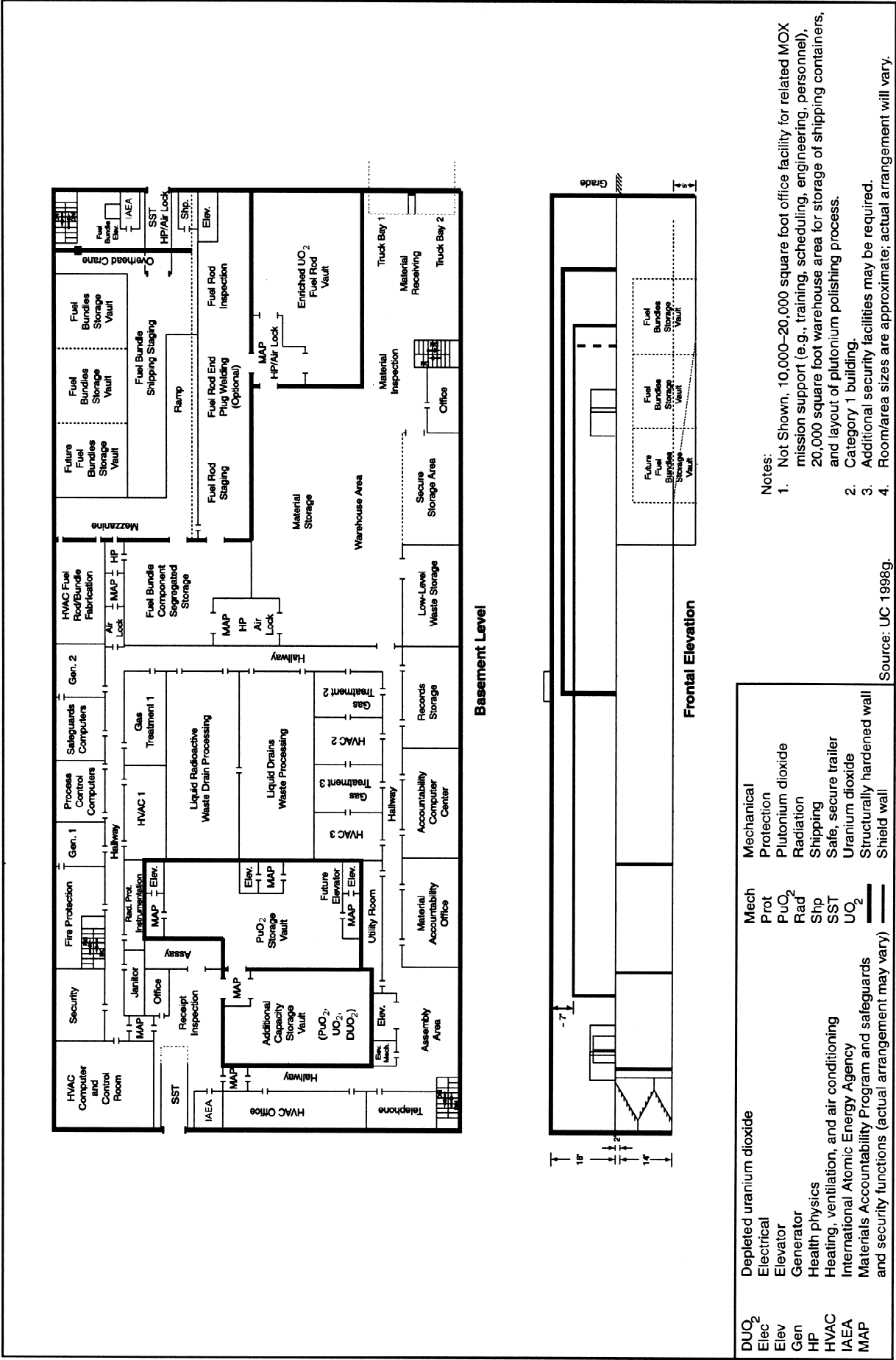


Figure 2-15. General Design of MOX Facility—Basement Level and Frontal Elevation

would provide backup power for critical systems. This arrangement would ensure continued operation of critical systems during any interruption of offsite power.

The basement level of the MOX facility would contain areas for support activities, including special nuclear material vault areas; general shipping and receiving docks; a general warehouse area; radioactive waste storage; assay facilities; emergency generators; heating, ventilation, and air-conditioning equipment; process gas and waste processing and treatment areas; the fuel rod fabrication area; and the fuel bundle assembly, storage, and shipping areas. Separate truck bays would be designed to accommodate the DOE SST/SGTs that would be used to transport the plutonium dioxide powder and the unirradiated fuel assemblies. Access control, office space, and warehouse facilities have been proposed for areas outside the secure MOX facility building. Facilities to support international or bilateral inspection and oversight activities would also be provided. Existing DOE site security and emergency services and environmental monitoring would support the MOX fuel fabrication mission.

MOX fuel is made from a mixture of plutonium dioxide and uranium dioxide. The uranium dioxide would be received from a commercial, NRC-licensed conversion facility. Conversion services for low-enriched uranium hexafluoride are commercially available in the United States at five facilities. As explained in Sections 2.4.4.2 and 2.4.4.3, for purposes of the analyses in this SPD EIS, the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, was analyzed as the representative facility for the source of depleted uranium hexafluoride to be converted into uranium dioxide.¹³ An NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, was used as a representative conversion facility.

2.4.3.2 MOX Fuel Fabrication Process

Figure 2–16 provides an overview of the MOX fuel fabrication process. The vast majority of the MOX fuel matrix, about 95 percent, is uranium dioxide. MOX fuel fabrication is essentially the same process that is used to produce low-enriched uranium fuel for commercial nuclear power reactors, once the plutonium and uranium dioxide powders are blended together into a mixed oxide. Processing of feed materials would begin with the plutonium-polishing process to remove gallium, but the process would also remove other impurities, including americium, aluminum, and fluorides. This process would include three elements: dissolution of the plutonium in nitric acid, removal of impurities by chemical separation (solvent extraction), and conversion of the plutonium back to an oxide powder by precipitation. Acid recovery steps, by which nearly all the nitric acid would be recovered and reused in the process, would also be included.

To begin the process, plutonium dioxide feedstock would be dissolved in near-boiling nitric acid with a silver nitrate catalyst. This solution would then be transferred to the solvent extraction process. Following solvent extraction, the plutonium would be converted from a nitrate solution back to an oxide powder through an oxalate precipitation, filtration, and calcination process. The resulting plutonium dioxide, verified to meet fabrication requirements, would then be transferred into containers for storage until needed, or transferred directly to the MOX fuel fabrication steps.

MOX fuel fabrication would begin with blending and milling the plutonium dioxide powder to ensure general consistency in enrichment and isotopic concentration. The uranium and plutonium powders would be blended and milled together to ensure uniform distribution of the plutonium in the MOX, and to adjust the particle size of the MOX powder. The MOX powder would then be made into pellets by pressing the powder into shape, sintering (baking at high temperature) the formed pellets, and grinding the sintered pellets to the proper

¹³ In July 1999, DOE submitted its *Final Plan for the Conversion of Depleted Uranium Hexafluoride* to Congress and is finalizing a request for proposals for, among other depleted uranium hexafluoride management activities, construction and operation of a depleted uranium hexafluoride conversion facility at one or more gaseous diffusion plants.

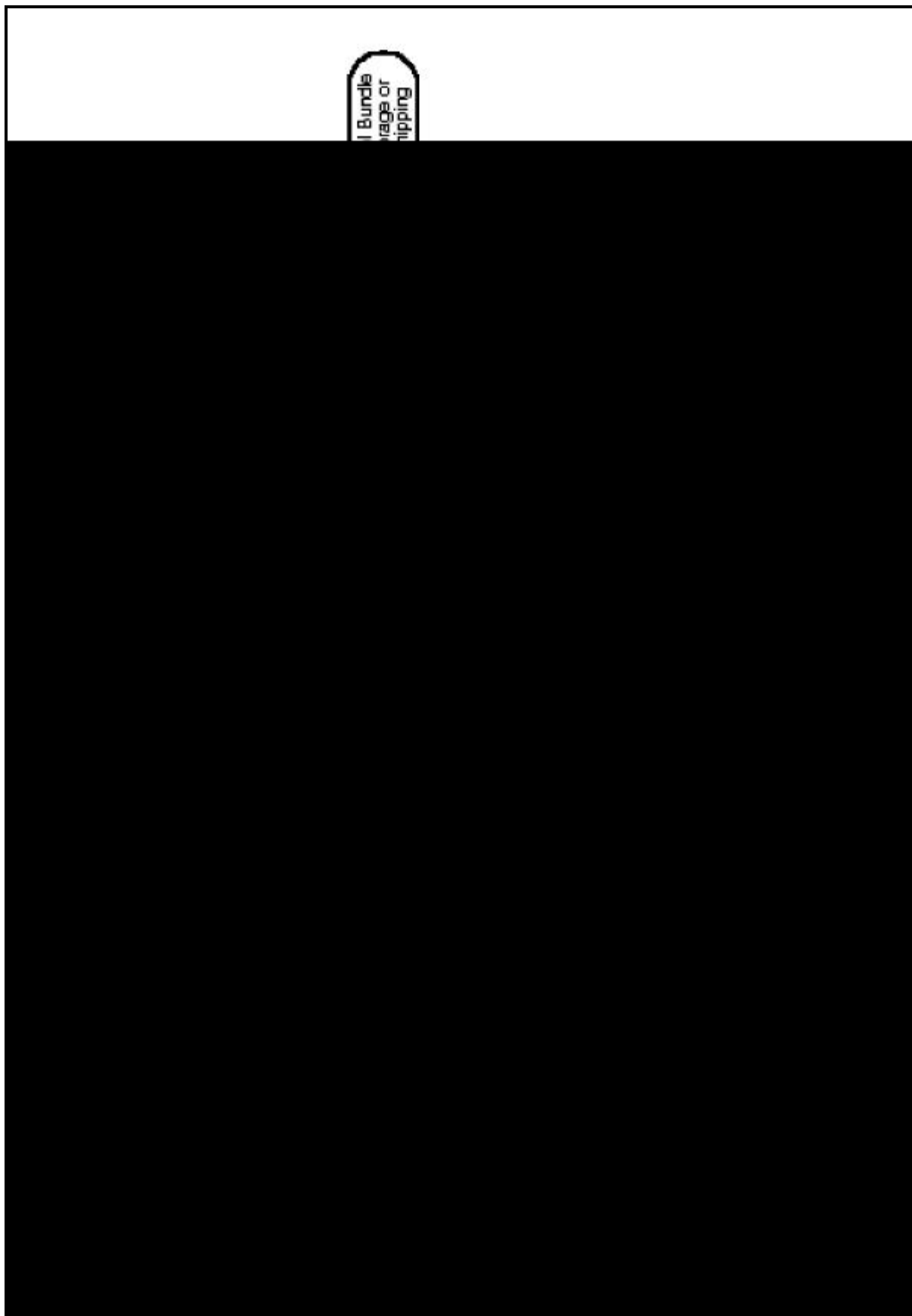


Figure 2-16. MOX Fuel Fabrication Process

dimensions. Materials and pellets would be inspected at each stage, and any rejected materials would be returned to the process for reuse. Most operations would be performed in sealed gloveboxes with inert atmospheres. Sintering furnaces would also be sealed, and offgases would be filtered and monitored prior to release to the atmosphere.

The finished pellets would be moved to the fuel rod fabrication area, where they would be loaded into empty rods. The rods would be sealed, inspected, and decontaminated, then bundled together to form fuel assemblies. Fuel assemblies would consist of only MOX rods or a mixture of MOX and low-enriched uranium rods. Low-enriched uranium rods used in fuel assembly fabrication would be fabricated at another of the fuel fabricator's facilities and brought to the MOX facility for final assembly with the MOX rods. Any rejected fuel bundles would be disassembled, and the materials recycled. Usable rods would be reassembled into new fuel assemblies. Pellets from rods not meeting final product specifications would be crushed and returned to the fabrication process, and decontaminated tubes and hardware would be recycled offsite as scrap metal. Storage for 2 years' production of fuel assemblies would be provided at the MOX facility. Individual fuel assemblies could be stored for that long prior to shipment to the designated domestic, commercial reactor, although production is anticipated to closely follow product need.

The plutonium-polishing process would produce aqueous waste containing the separated impurities (e.g., gallium, americium, aluminum, and fluorides). The liquid wastes from the various impurity removal processes would be transferred to a waste feed tank for evaporation and chemical treatment as required. The evaporator condensate would be treated to produce concentrated acid and acidified water for reuse. The evaporator concentrate would be chemically denitrated, and the offgas from the denitrator scrubbed to produce concentrated nitric acid for reuse. The impurities removed during these processes would be concentrated and solidified for disposal as TRU waste.

Solid wastes generated from process operations would include glovebox gloves, equipment, tools, wipes, and glovebox and HEPA filters. These materials would be removed from the process glovebox lines and transferred to a waste packaging glovebox. Nonprocess materials would be decontaminated to remove residual plutonium. The plutonium would be returned to the dissolution step, and the waste materials would be packaged, assayed, and disposed of as either TRU or LLW, as appropriate.

2.4.4 Transportation Activities

The plutonium disposition alternatives examined in this SPD EIS would require DOE to ship surplus plutonium-bearing materials from their current storage locations, shown in Figure 1–1, to the proposed disposition facility locations for processing. Table 2–3 is an overview of the different types of shipments that would be required for each proposed disposition facility and the vehicles in which the shipments would be made.

The overland transportation of any commodity involves a risk to both the transportation crew and members of the public. The risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of hazardous or radioactive materials poses an additional risk due to the unique nature of the material being transported. Chapter 4 and Appendix L discuss the risks associated with the transportation of these materials and the steps that would be taken to mitigate these risks as they relate to this SPD EIS.

Table 2–3. Facility Transportation Requirements

Required Shipment	Vehicle ^{a, b}
Pit Conversion Facility	
Intersite shipment of surplus pits and clean metal to the pit conversion facility	SST/SGT
Recovered HEU from the pit conversion facility to ORR	SST/SGT
[Text deleted.]	
Plutonium dioxide to the immobilization or MOX facility	SST/SGT
Immobilization Facility	
Under Alternatives 11B and 12B, plutonium dioxide from the pit conversion facility ^c	SST/SGT
Surplus nonpit plutonium to the immobilization facility ^d	SST/SGT
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a conversion facility (ceramic immobilization option only) ^e	Commercial truck
Uranium dioxide from the conversion facility to the immobilization facility (ceramic immobilization option only)	Commercial truck
Immobilized plutonium from immobilization facility to the HLW vitrification facility (intrasite transport)	Special transport vehicle
Vitrified HLW with immobilized plutonium to a potential geologic repository	Commercial truck
MOX Facility^f	
Under Alternatives 4 and 5, plutonium dioxide from the pit conversion facility ^g	SST/SGT
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a commercial conversion facility ^e	Commercial truck
Uranium dioxide from the conversion facility to the MOX facility	Commercial truck
Uranium fuel rods from a commercial fuel fabrication facility to the MOX facility ^h	Commercial truck
MOX fuel bundles to selected domestic, commercial reactors	SST/SGT
MOX spent fuel from domestic, commercial reactors to a potential geologic repository ⁱ	Commercial truck
Lead Assembly Fabrication Facility	
Plutonium dioxide from LANL to a lead assembly facility at a location other than LANL	SST/SGT
For lead assembly fabrication at LANL, intrasite movement of plutonium materials	Special transport vehicle
Depleted uranium hexafluoride from one of DOE's sites at a gaseous diffusion plant to a commercial conversion facility ^e	Commercial truck
Uranium dioxide from the conversion facility to the lead assembly facility	Commercial truck
Uranium fuel rods from a commercial fuel fabrication facility to the lead assembly facility	Commercial truck
MOX fuel bundles to the selected domestic, commercial reactor	SST/SGT
Irradiated lead assemblies or rods from the reactor to an examination site	Commercial truck
Spent fuel from an examination site to INEEL for storage ^j	Commercial truck
Spent fuel from INEEL to a potential geologic repository ⁱ	Commercial truck

^a All containers and vehicles will meet Department of Transportation requirements.

^b Commercial trucks will be driven by drivers certified to meet all radioactive materials transportation requirements.

^c Under Alternatives 11A and 12A, the two facilities would be collocated; therefore, the transfer of the plutonium dioxide would not require any over-the-road transportation.

^d For cases where the surplus nonpit plutonium requires offsite transportation.

^e DOE is considering building one or more facilities at the gaseous diffusion plant(s) to convert depleted uranium hexafluoride to an oxide form.

^f Some equipment for the MOX facility may be manufactured in Europe and shipped to the United States. No nuclear or radiologically contaminated materials would be transported. Any such shipments would be made by commercial vessel, and no impacts other than those occurring from routine commercial shipping would be expected.

^g Under Alternatives 2, 3, 6A, 6B, 7, 8, 9, and 10, the two facilities would be collocated; therefore, the transfer of the plutonium dioxide would not require any over-the-road transportation.

^h For cases where the fuel assemblies are a combination of MOX and low-enriched uranium fuel rods.

ⁱ Shipments of spent fuel are analyzed in the *Draft EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*.

^j Shipments of spent fuel within the DOE complex are analyzed in the *DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final EIS*.

Key: HEU, highly enriched uranium; HLW, high-level waste; LANL, Los Alamos National Laboratory; ORR, Oak Ridge Reservation; SST/SGT, safe, secure trailer/SafeGuards Transport.

2.4.4.1 Pit Conversion Transportation Requirements

To implement any of the disposition alternatives being considered in this SPD EIS, clean plutonium metal and surplus pits would need to be shipped from current storage locations around the DOE complex to the proposed location of the pit conversion facility. Due to the attractiveness of these materials for use in constructing nuclear weapons, all intersite shipments would be made in DOE SST/SGTs.¹⁴ In the alternatives that include locating the pit conversion facility at Pantex, where surplus pits are stored, the transfer of the surplus pits from onsite storage to the pit conversion facility would be made in specially designed transport vehicles that are routinely used to transport pits around the site. This would reduce the number of intersite trips and the distance that would have to be traveled to transport pits to the pit conversion facility. Also, as discussed in Appendix L, the dose associated with transferring the pits from storage to the pit conversion facility at Pantex could be reduced because the pits would be transferred from current storage locations to the pit conversion facility without being repackaged into the shipping containers that would be required for intersite transport.

After conversion, the plutonium from the pit conversion facility would be in the form of plutonium dioxide. For most of the alternatives, this material would be transferred from the pit conversion facility to either the immobilization or MOX facility through a secure underground tunnel. In Alternatives 6B and 11A, where the pit conversion facility is collocated in the same building with another disposition facility, the plutonium dioxide would be transferred within the building. However, several alternatives (4A, 4B, 5, 11B, and 12B) locate the pit conversion facility at Pantex and immobilization and/or MOX facilities at another site. The reason for including these alternatives is that the vast majority of the surplus pits are stored at Pantex. Less intersite transportation would be required to move these pits to the pit conversion facility, and the doses associated with repackaging pits into shipping containers at Pantex would be avoided. Under these alternatives, the plutonium dioxide from the pit conversion facility would be shipped in SST/SGTs to the other proposed disposition facilities.

HEU recovered during the pit disassembly process would be shipped via SST/SGT to ORR for declassification, storage, and eventual disposition.¹⁵ The HEU would be decontaminated at the pit conversion facility, and would meet Y-12 acceptance criteria prior to shipment.

2.4.4.2 Immobilization Transportation Requirements

Figure 2-17 shows the transportation requirements for the proposed immobilization disposition activities. Surplus nonpit plutonium in various forms would be moved from current storage locations (i.e., Hanford, INEEL, LLNL, LANL, the Rocky Flats Environmental Technology Site [RFETS], and SRS) to the proposed immobilization facility location, either Hanford or SRS. The quantity of plutonium contained in these materials dictates that they be subjected to the same safeguards and security requirements as materials that could be used in nuclear weapons. Therefore, intersite shipments would be made in SST/SGTs.

¹⁴ The SST/SGT is a specially designed component of an 18-wheel tractor-trailer vehicle. Although the details of the vehicle enhancements are classified, key characteristics are not, and include: enhanced structural supports and a highly reliable tie-down system to protect cargo from impact; heightened thermal resistance to protect the cargo in case of fire; deterrents to protect the unauthorized removal of cargo; couriers who are armed federal officers and receive rigorous training and are closely monitored through DOE's Personnel Assurance Program; an armored tractor to protect the crew from attack and advanced communications equipment; specially designed escort vehicles containing advance communications and additional couriers; 24-hr-a-day real-time monitoring of the location and status of the vehicle; and significantly more stringent maintenance standards.

¹⁵ Shipments would be in accordance with the *Environmental Assessment for the Proposed Interim Storage of Enriched Uranium Above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee* (DOE/EA-0929, September 1994; FONSI, September 1995). Storage would be in accordance with the ROD for the *Storage and Disposition PEIS*; disposition would be in accordance with the ROD for the *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (61 FR 40619, August 5, 1996).

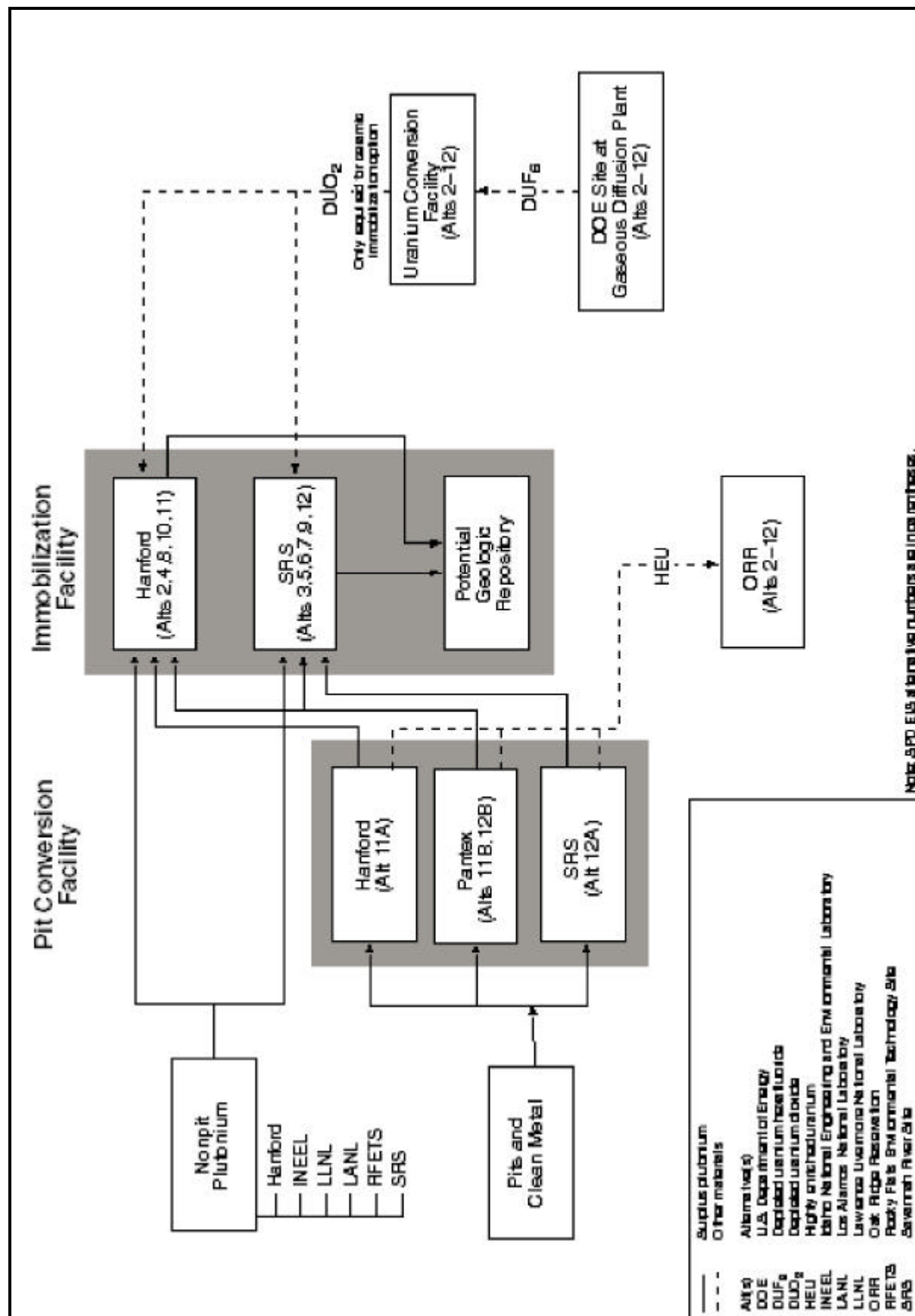


Figure 2-17. Transportation Requirements for Plutonium Conversion and Immobilization

For Alternatives 11 and 12, where all the surplus plutonium would be immobilized, the plutonium dioxide from the pit conversion facility would also be transferred to the immobilization facility. For Alternative 11A, both facilities would be collocated in FMEF and the transfer would take place within the same building. For Alternative 12A, the transfer would be made between the two facilities at SRS through a secure underground tunnel and would not require any vehicular transportation. [Text deleted.] However, as discussed in Section 2.4.4.1, for Alternatives 11B and 12B, the plutonium dioxide would be shipped from the pit conversion facility at Pantex to the immobilization facility at either Hanford or SRS in SST/SGTs.

Surplus plutonium destined for immobilization would be immobilized in either a ceramic or glass form, placed in small stainless steel cans and then into HLW canisters at the immobilization facility. The canisters would then be transported in specially designed intrasite transport vehicles to an HLW vitrification facility (either DWPF at SRS, or the planned HLW vitrification facility at Hanford). In keeping with the current practice at these sites for this type of shipment, this intrasite transportation could require roads at Hanford or SRS to be closed temporarily while the material would be transported from one area of the site to another. This practice would provide all needed security measures and mitigate potential risk to the public, without requiring the use of SST/SGTs for intrasite transfers.

Immobilization alternatives at Hanford could involve the transfer of plutonium between FMEF and the immobilization annex. This transfer would occur either through an underground tunnel or by surface vehicle within the protected security zone.

Immobilization of the plutonium as a ceramic material also requires a small amount of depleted uranium dioxide (i.e., less than 10 t/yr [11 tons/yr]) as discussed in Section 2.4.2.2.2. This depleted uranium dioxide could be produced by shipping depleted uranium hexafluoride from one of DOE's storage areas at a gaseous diffusion plant in Kentucky, Ohio, or Tennessee via commercial truck to a commercial site for conversion to depleted uranium dioxide. Possible sites for this conversion include nuclear fuel fabrication facilities in Missouri, North Carolina, South Carolina, or Washington, or a uranium conversion facility in Illinois. After conversion at one of these sites, the uranium dioxide would be shipped on a commercial truck to either Hanford or SRS for use in the immobilization facility. Because the risks associated with transporting either depleted uranium hexafluoride or depleted uranium dioxide are extremely low, the shipments could be made to or from any of the locations discussed above and not significantly affect the overall risks associated with the transportation required in this SPD EIS. For the purposes of quantifying the transportation analysis in this SPD EIS, it was assumed that the depleted uranium hexafluoride would be shipped from the DOE facility at the Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, to an NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, for conversion.

After the immobilized plutonium would be encased by HLW at the HLW vitrification facility, it would eventually be shipped to a potential geologic repository for ultimate disposal. Because the cans of immobilized plutonium would displace some of the HLW that would otherwise fill the canister, additional canisters would have to be filled over the life of the immobilization program to address this displaced HLW. It is estimated that up to 395 additional canisters of HLW would result from the decision to immobilize all 50 t (55 tons) of surplus plutonium. The *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain Draft EIS)*, (DOE 1999b) analyzed a number of different options for the shipment of these canisters using either trucks or trains. The analysis in the *Yucca Mountain Draft EIS* indicated that the risks would be lower if the canisters were shipped by train. However, no ROD has been issued regarding these shipments. To bound the risks, this SPD EIS has taken the most conservative analytical approach (i.e., the approach that results in the highest risk to the public) and assumed that all of these shipments would be made by truck to the potential geologic repository, with one canister being loaded on each truck.

2.4.4.3 MOX Transportation Requirements

To implement the MOX disposition alternatives being considered in this SPD EIS, plutonium dioxide from the pit conversion facility would have to be transferred to the MOX facility. Under all the MOX alternatives except Alternatives 4A, 4B, and 5, the pit conversion and MOX facilities would be located at the same site. Figure 2–18 shows the transportation requirements for the proposed MOX disposition activities. For Alternative 6B, the transfer would take place within the same building (FMEF). Under Alternatives 2, 3, 6A, 7, 8, 9, and 10, current designs assume that facility materials would be transferred between the two facilities through a secure, underground tunnel. No vehicular transportation over public roads would be required for any of these alternatives. However, as discussed in Section 2.4.4.1, for Alternatives 4A, 4B, and 5, the plutonium dioxide would be shipped in SST/SGTs from the pit conversion facility at Pantex to the MOX facility at either Hanford or SRS.

MOX fuel fabrication also requires uranium dioxide. Depleted uranium dioxide could be produced by shipping depleted uranium hexafluoride from one of DOE's storage areas at a gaseous diffusion plant in Kentucky, Ohio, or Tennessee via commercial truck to a commercial site for conversion to depleted uranium dioxide. Possible sites for this conversion include nuclear fuel fabrication facilities in Missouri, North Carolina, South Carolina, or Washington, or a uranium conversion facility in Illinois. After conversion at one of these sites, the uranium dioxide would be shipped on a commercial truck to Hanford, INEEL, Pantex, or SRS for use in the MOX facility. Because the radiological risks associated with transporting either depleted uranium hexafluoride or depleted uranium dioxide are extremely low, the shipments could be made from or to any of the locations discussed above and not significantly change the overall risks associated with the transportation required in this SPD EIS. For the purposes of quantifying the transportation analysis in this SPD EIS, representative sites for obtaining the depleted uranium dioxide were chosen. The Portsmouth Gaseous Diffusion Plant near Piketon, Ohio, represents the source of the depleted uranium hexafluoride and an NRC-licensed commercial nuclear fuel fabrication facility in Wilmington, North Carolina, represents the conversion facility.

After conversion, the depleted uranium dioxide would be shipped on a commercial truck from the conversion facility to the MOX facility. After fabrication, the MOX fuel would be shipped to Catawba, McGuire, or North Anna where it would be inserted into the reactor and irradiated. These shipments would be made in SST/SGTs because unirradiated MOX fuel in large enough quantities is subject to security concerns similar to those associated with weapons-grade plutonium. [Text deleted.]

It is also possible that some equipment for the MOX facility may be manufactured in Europe and shipped to the United States. No nuclear or radiologically contaminated materials would be transported. Any such shipments would be made by commercial vessel, and no impacts other than those occurring from routine commercial shipping would be expected.

2.4.4.4 Lead Assembly and Postirradiation Examination Transportation Requirements

To implement the MOX disposition alternatives being considered in this SPD EIS, MOX fuel assemblies would be fabricated, irradiated, and tested before the actual production of MOX fuel. Figure 2–19 shows the transportation requirements for the proposed lead assembly activities. As described in Section 2.17, plutonium dioxide from the Pit Disassembly and Conversion Demonstration Project at LANL would be shipped in SST/SGTs to one of four candidate DOE facilities (Hanford, ANL–W, LLNL, or SRS), or remain at LANL, for fabrication into lead assemblies. If the lead assemblies were to be fabricated at LANL, the plutonium dioxide would be transferred from the pit conversion demonstration to the lead assembly fabrication area within the same plutonium processing building (PF–4), in Technical Area 55 (TA–55), for MOX pellet production. Any intrasite transfers of plutonium outside of TA–55 would be in special vehicles in accordance